Low Delta T Stirling Engine

SE-8576A

Introduction

The PASCO SE-8576A Low Delta T Stirling Engine is a jewel-like engine. Because of its precision components and careful construction, it can operate on temperature differences as small as four degrees celsius (4 °C).

For example, when the room temperature is 22.2 °C (72 °F) or cooler, the heat from a warm hand is enough to power the engine.

Stirling engines can be very efficient with some designs attaining efficiencies up to 50% of the Carnot Cycle efficiency. The Carnot Cycle determines the maximum theoretical efficiency of a heat engine according to the formula:

$$\frac{\text{temp hot - temp cold}}{\text{temp hot}} = \%\ \text{efficiency}$$

where the temperature is measured in absolute degrees (kelvin (K) or rankine).

Operation

The Low Delta T Stirling Engine operates as follows:

The bottom plate of the engine along with the clear acrylic cylinder, the top plate, and the graphite power piston make up a sealed system. When the air inside this system changes temperature, so does the pressure.

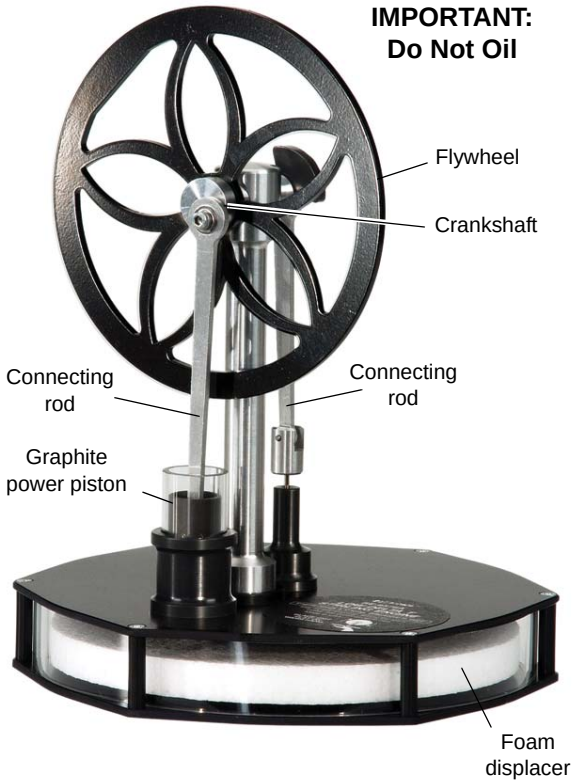
Inside the clear acrylic cylinder is a large white foam *displacer.* This displacer looks like a piston, but it has a 3.125 mm (1/8” inch) gap around its outer edge. Air never pushes on the displacer; it flows around the displacer.

The engine can begin working when either the bottom plate or the top plate is heated or cooled to a temperature at least 4 °C warmer or cooler than the other plate. A gentle spin on the flywheel is needed to start the engine.

As the foam displacer moves away from the warm side of the engine, air flows around the edge of the displacer toward the warm side and is heated. When the air is heated, it expands, which increases the pressure inside the entire engine. This increase in air pressure pushes up on the graphite power piston.

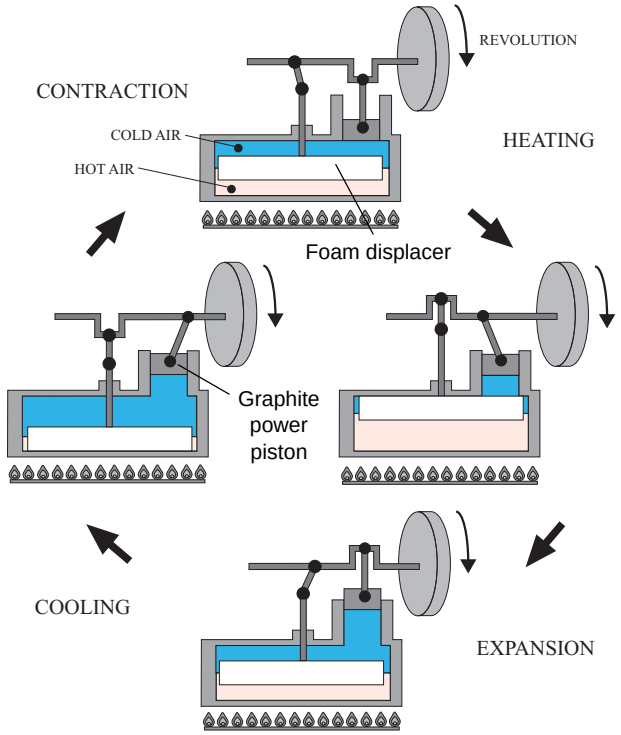
Next, the energy stored in the flywheel moves the displacer closer to the warm side of the engine, and the air once again flows around the edge of the displacer toward the cool side of the engine.

When the air is cooled, it contracts, and the pressure drops throughout the engine. The pressure inside the engine becomes less than the pressure outside, and the graphite power piston is pushed down. The displacer moves back toward the cool side, the air is displaced toward the warm side, and the cycle starts all over again.



The foam displacer only moves the air back and forth from the warm side to the cool side of the engine. It does not do any work on the crankshaft. In other words, the connecting

rod to the displacer could be a string and the engine would still work.



Operation of a displacer type Stirling Engine

Usage

Place the Low Delta T Stirling Engine on the palm of your ward hand with the label toward you. After the engine has warmed up for a couple of minutes, gently spin the flywheel in a clockwise direction to get it started.

NOTE: Hand temperatures vary widely. Not everyone has warm enough hands to make this engine run. If your hands are cool, find someone with warm hands to try this.

You can also run the engine in the opposite direction by placing the bottom plate on a cold object, letting it cool down, and then gently spinning the flywheel in the counterclockwise direction.

Maintenance

- Dust is the number one enemy of this engine. Cover it when it is not in use.
- It is a good idea to store it in a plastic case.
- Never oil the engine.
- Do not store the engine where it will be exposed to bright sunlight or the colors will fade.
- Handle with care. The Low Delta T Stirling Engine is a delicately balanced precision engine and it is very fragile.

Troubleshooting

Generally there are three reasons why Stirling engines fail to run: too much friction, air leaks, or inadequate thermal transfer. The most likely reason for the Low Delta T Stirling Engine to fail to run is inadequate thermal transfer.

If the engine will not run, try the following:

Put 2.5 cm (1 inch) of water in the bottom of a coffee mug. Heat the water until the water is boiling vigorously. Carefully remove the mug from the heat source, and place the engine on top of the mug. Wait for 15 seconds, and then gently spin the flywheel. Try spinning the flywheel in both directions if it fails to start in a minute or so.

If the engine will not run when you try this test, it needs to be returned for maintenance.

A Brief History of the Stirling Engine

The Reverend Robert Stirling, a minister of the Church of Scotland, was troubled by some of the dangerous engines that were used at the beginning of the industrial revolution. Steam engines would often explode with tragic effects to anyone unfortunate enough to be standing nearby. So in 1816 he invented and patented “A New Type of Air Engine with Economizer”.

Robert Stirling realized that the engines he built would be more efficient if some of the heat that was used to warm the air for one cycle was saved and used again in the next cycle. He called the device that saved the heat an “economizer”. Today, this is usually called a “regenerator”, and is probably Robert Stirling’s most important invention.

“Hot air engines”, as they were initially called, couldn’t explode and often produced more power than the steam engines of their day. The problem was that the only readily available metal in the early 1800s was cast iron, which oxidizes rapidly when left in a very hot flame.

Despite this difficulty, Stirling engines were widely used as water pumping engines at the turn of the century. They required little service, never exploded, were fairly quiet, and the water provided a good cooling source for the cool side of the engine. Thousands of these engines were sold

The Low Delta T Stirling Engine

.In 1983, Ivo Kolin, a professor at the University of Zagreb (in what was then Yugoslavia) demonstrated the first Stirling engine that would run on small temperature differences. After he published his work, Dr. James Senft, a mathematics professor at the University of Wisconsin - River Falls (United States), built the first engines similar to the PASCO Low Delta T Stirling Engine.

The Carnot Energy Cycle

In the mid 1800s, a Frenchman named Sadi Carnot figured out the maximum limits of efficiency. His formula is an accepted standard for determining the maximum possible

efficiency of an engine. No engine can exceed the Carnot efficiency. (The second law of thermodynamics says you can't get out more than you put in; you can only break even.) It takes good engineering and complex machines to achieve a significant fraction of the Carnot efficiency. Real Stirling engines can reach 50 percent of the maximum theoretical value, which is a very high percentage.

Stirling Engines Today

The modern uses of Stirling engines are invisible to almost everyone. There have been many research engines built in recent years, but there are only three areas where Stirling engines have made a dramatic impact. These are Stirling engines in submarines, in cryocoolers, and in science classrooms.

Cryogenics is the science of things that are very cold, and Stirling engines can be used to produce extremely cold temperatures. It's not obvious, but a Stirling engine is reversible. If you warm one side and cool the other, you get mechanical work out. However, if you mechanical work in, by connecting an electric motor, for example, one side will get hot and the other will get cold. In a correctly designed Stirling engine, the cold side will get extremely cold. In fact, Stirling engines used as cryocoolers have been made that will cool below 10 kelvin (K). Micro-sized Stirling engines have been produced in large numbers for cooling infrared chips down to 80 K for use in night vision goggles and infrared cameras.

Since Stirling engines are so efficient, an obvious question is: Why doesn't my car have one?

Although a variety of prototype Stirling engine powered cars have been developed, they have not gained popularity because that have to warm up for 30 seconds to a minute before they will move. Most consumers have not been willing to wait that long to get started. The low gas prices of the 1980s and 1990s did not provide an economic incentive for consumers to switch to Stirling engines, and automobile companies have not had the incentive to research and develop more saleable engine designs.

Stirling Engines in the Future

Future uses of Stirling engines could include applications in the maritime and aviation industries. Stirling engines would work exceptionally well for auxiliary power generators on pleasure boats, where their silence and efficiency would be value, and cooling water is plentiful. Some research has already been done in this area: the French research submarine "Saga" is Stirling engine powered. Stirling engines would also work very well in airplanes where the air gets cooler as the plane climbs to altitude. Stirling engines would not lose as much power as they climb as conventional piston engines or jet engines. Stirling engines would operate with very low levels of vibration and noise.

Technical Support

For assistance with any PASCO product, contact PASCO at:

Address:	PASCO scientific 10101 Foothills Blvd. Roseville, CA 95747-7100
Phone:	+1 916 786 3800 (worldwide) 800-772-8700 (U.S.)
Web:	www.pasco.com
Email:	techsupp@pasco.com

For more information about the Low Delta T Stirling Engine and the latest revision of this Instruction Sheet, go to the PASCO web site at www.pasco.com and enter SE-8576A in the Search window.

Limited Warranty For a description of the product warranty, see the PASCO catalog. **Copyright** The PASCO scientific 012-06870B *Low Delta T Stirling Engine Instruction Sheet* is copyrighted with all rights reserved. Permission is granted to non-profit educational institutions for reproduction of any part of this manual, providing the reproductions are used only in their laboratories and classrooms, and are not sold for profit. Reproduction under any other circumstances, without the written consent of PASCO scientific, is prohibited. **Trademarks** PASCO and PASCO scientific are trademarks or registered trademarks of PASCO scientific, in the United States and/or in other countries. All other brands, products, or service names are or may be trademarks or service marks of, and are used to identify, products or services of, their respective owners. For more information visit www.pasco.com/legal.